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Kvittering for modtagelsen bedes mærket **"datatransmission"**

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Low rate wavelet based data transmission

Low rate wavelet based data transmission

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Aalborg University, January 17th 2000
By Anders la Cour-Harbo and Jakob Stoustrup

Introduction

We propose a method for adaptively designing the set of commands which are used in low rate data transmission such as in a remote control for a consumer electronics product, e.g. a compact disc player. In a typical setup the set of commands, the *alphabet*, is designed to accommodate a worst case situation with respect to perturbation of the transmitted commands, the *letters* of the alphabet. Since this situation rarely arises an unnecessary redundancy exists in such a system. We therefore propose a method for designing an alphabet which suits a particular situation, and which can be redesigned whenever improvements are achievable by doing so. The design parameters are based on previous transmissions. The design of the letters, the signals to be transmitted, are done using well-known time domain methods and the wavelet transform.

The invention is the combination of complete design freedom of the letters in the time domain and the use of the wavelet transform to construct a suitable alphabet, to decode received signals, and to extract properties of the transmission. The latter is useful for redesigning the alphabet and for adjusting the parameters of the wavelet transform in any future transmission.

Note that "low rate" refers to the use of an alphabet, where each letter consists of certain amount of information, which typically has a high redundancy to improve robustness. Note also that due to the huge variety of terminology in the broad area of data transmission, the words "low rate", "letter", and "alphabet" might be different in relevant literature.

Background

The transmission of one of a finite set of letters, an alphabet, is known prior to this invention. There also exist various methods for generating an alphabet, such that each letter has a unique signature. This invention is mainly a new method for generating such alphabets.

In the following a remote control system for a compact disc player is used for descriptive purposes. This does not mean that the described method is limited to this application. It should however be fairly straight-forward from the description below for experts in any relevant field how to incorporate the method in other applications.

In a typical setup the communication between the remote control and the compact disc player consists of a number of commands, such as "Play", "Pause", "Stop", transmitted from the remote control to the compact disc player. Each command consists of a unique, predetermined signal with finite temporal extension, in this document referred to as a letter. Each letter must fulfill the following to opposing requirements: It most contain enough information to ensure a sufficiently high probability of reception and correct interpretation, and not contain more information than can be transmitted within a sufficiently short period of time. Moreover it is desirable to minimize the energy consumption of the remote control,

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and hence the amount of energy used for transmission should be as low as possible, again requiring a minimum of transmitted information.

It is therefore desirable to use an alphabet which is tailored to the particular circumstances including noise from various sources, distortion of the transmitted signal, changes in electronic equipment due to aging, temperature changes, and in wireless communications dust and dirt on the emitter and receiver. Since the circumstances are usually not known very accurately prior to implementation, it is necessary to use an alphabet which has "a high probability of success", i.e. the alphabet can deliver the desired information in a given worst case scenario. This inevitably leads to unnecessary redundancy in most events of transmission, that is when the conditions are more lenient than in the worst case scenario.

Description of the Invention

This invention is concerned with the design of an alphabet. We propose to design the letters as signals in the time domain followed by a wavelet transform. From a mathematical point of view, it is a fairly simple task to design a limited number of temporal signals which have the property of both easy and complete distinction. One example is orthogonal signals. Transmitting a signal designed in the time domain can, however, be troublesome, since the perturbation of the signal during transmission often occurs in both the time and the frequency domain.

Hence the invention is to apply the wavelet transform to each letter prior to transmission, and to utilize properties of the wavelet transform in conjunction with the redundancy in the transmitted signal to determine some properties of the perturbation of the signal upon reception. This in turn can lead to actions such as retransmission, an perturbation of the alphabet (i.e. redesigning some or all of the letters), determination of noise and/or distortion properties, fixing damaged signals, and reduced precision for damaged or partly received signals. Some of the proposed actions require two way communication.

The possibility for these different actions reduces the requirements for the amount of information needed in the alphabet, partly because this method can cope with lost and damaged signals, partly because it is possible to design an alphabet which suits any particular situation, eliminating the need for an alphabet capable of handling a worst case situation which is not realistic.

The wavelet transform itself has a number of properties which make it specifically appropriate to the application. These include: linearity, preservation of energy, perfect reconstruction, easy implementation, low computational complexity, good handling of short signals, and proportionality of perturbations in a signal before and after transformation.

To demonstrate how a transmission is done, and how the wavelet transform is exploited, the following is a description of transmission of a single letter. A time domain signal is designed and wavelet transformed. If information about the noise is available prior to transmission this can be used to tailor the signal and the particular wavelet transform employed to reduce the impact of the noise. If for instance the noise is concentrated in a particular frequency band the signal and the wavelet transform is adjusted to use other frequencies.

The transmission of the signal introduces some unknown perturbations of the signal. Upon reception the signal is inversely transformed. Due to the many properties of the wavelet transform, some described above, it is in most cases - even under severe noise conditions - possible, to determine which of the

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possible letters were transmitted. Once the letter is determined this inf rmation can be subtracted from the received signal, yielding information about the perturbation, in particular the n ise contribution, which occurred during transmission. Should the received signal be unidentifiable the signal can be retransmitted with another time-frequency signature.

The freedom to design and redesign the transmission signals combined with the means for reallocating the signal in time and frequency, makes it possible to accommodate for virtually any type of perturbation. Moreover it is possible to adapt the alphabet to a given situation, which incidentally reduces the need for information whenever the perturbations are small or vanishing.

Suggestion for hierarchy of claims

1. A method for designing an alphabet for use in low rate data transmission, comprising:
   (a) a design of letters in the time domain,
   (b) a wavelet transform of each letter prior to transmission,
   (c) a transmission of the signal,
   (d) an identification of the received signal with respect to the alphabet.
2. A method as defined in claim 1, further comprising an extraction of properties of the transmission upon reception of the transmitted signal.
3. A method as defined in claim 2, where the extracted properties are used for adjusting the parameters of the wavelet transform.
4. A method as defined in claim 3, where the extracted properties are used to decide one or more of a number of actions. These includes, but are not limited to, retransmission, restoration of damaged received signals, acceptance of reduced precision for damaged or partly received signals.
5. A method as defined in claim 4, where the alphabet is redesigned based on the extracted properties.
6. A method as defined in claim 5, where the extraction of properties are based on a inverse wavelet transform.
7. A method as defined in claim 6, where the letters are designed as orthogonal signals.
8. A method as defined in claim 7, where the alphabet is a set of commands equivalent to that of a remote control system.
9. A method as defined in claim 8, implemented in a wireless, infra red or ultra violet remote control system.